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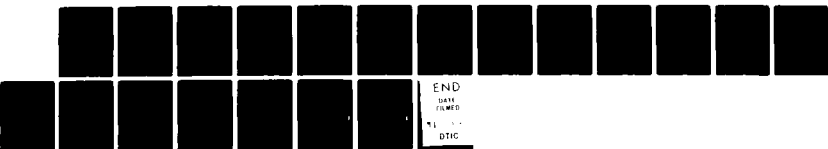
INSTALLATION OF A SINGLE-BUILDING ENERGY CONTROLLER AT
THE PUBLIC WORKS C..F.U) NAVAL CIVIL ENGINEERING LAB
PORT HUENEME CA K J CANFIELD SEP 83 NCEL-TN-1678

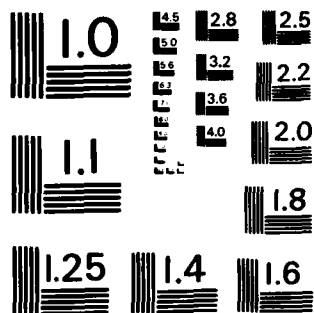
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TITLE: INSTALLATION OF A SINGLE-BUILDING ENERGY
CONTROLLER AT THE PUBLIC WORKS CENTER,
NAVAL WEAPONS CENTER, CHINA LAKE

AUTHOR: K. J. Canfield

DATE: September 1983

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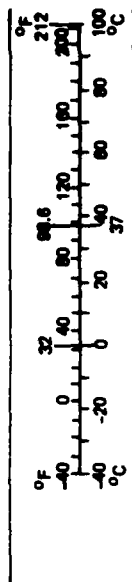
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi ²	square miles	2.6	square kilometers	km ²
	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
VOLUME				
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft ³	cubic feet	0.03	cubic meters	m ³
yd ³	cubic yards	0.76	cubic meters	m ³
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
km	kilometers	1.1	yards	yd
		0.6	miles	mi
AREA				
cm ²	square centimeters	0.16	square inches	in ²
m ²	square meters	1.2	square yards	yd ²
km ²	square kilometers	0.4	square miles	mi ²
ha	hectares (10,000 m ²)	2.5	acres	
MASS (weight)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m ³	cubic meters	35	cubic feet	ft ³
m ³	cubic meters	1.3	cubic yards	yd ³
TEMPERATURE (exact)				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



*1 in. = 2.54 (exact). For other exact conversions and more detailed tables, see NBS Misc. Publ. 288, Units of Weights and Measures, Price \$2.25, SD Catalog No. C13.10-288.

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20. Continued

and the patience and cooperation of the building occupants.

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CONTROLLER AT THE PUBLIC WORKS CENTER,
NAVAL WEAPONS CENTER, CHINA LAKE (Final), by
K.J. Canfield

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1. Energy conservation

2. Control systems

1. ZO371-01-221C

Single-building energy controllers can be installed in many buildings to conserve energy. These systems can provide significant energy savings with limited investment. This report details the installation of a single-building energy controller in the Public Works Center building at Naval Weapons Center, China Lake, Calif. The controller was installed by NCEL and Public Works personnel in about 3 days, and is working very well. The reasons for the success are a reliable controller, a dedicated user, and the patience and cooperation of the building occupants.

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INTRODUCTION

Energy conservation measures can be implemented in buildings to reduce energy consumption significantly. One attractive measure is to utilize single-building energy controllers (SBEC). These SBEC can implement very complex energy conservation control strategies and can pay for themselves in a very short time period. This report discusses the installation of an Andover Controls Sunkeeper in the Public Works building at the Naval Weapons Center (NWC), China Lake, Calif. The installation of the Andover Controls Sunkeeper does not imply endorsement by the Government. The Sunkeeper is one of many different single-building controllers (see Ref 1*) and may be no better or worse than any other controllers with similar characteristics.

BACKGROUND

The energy crisis of 1973 and increasing energy costs have caused great emphasis to be placed on energy conservation. A variety of ways is feasible for government installations to meet their energy conservation goals. Many large facilities are installing large-scale, computerized Energy Monitoring and Control Systems (EMCS) to help meet their goals. These systems have many advantages, a few of which are: energy conservation with limited manpower, energy accountability, and improved operation and maintenance of heating, ventilating, and air conditioning (HVAC) systems. Unfortunately, these EMCS are expensive and require cooperation and dedication of facility operation and maintenance (O&M) personnel.

There are many smaller installations and single buildings that cannot justify a large-scale EMCS. Equipment that can provide significant energy savings in these small installations or single buildings can be divided into six categories: time clocks, duty cyclers, demand limiters, programmable controllers, micro-EMCS, and small EMCS.

Guide specifications have been prepared for small EMCS and micro-EMCS. A small EMCS would have at least a part-time operator, while a micro-EMCS would be installed and only rarely would changes in the operation of the system be made. Typical energy conservation control strategies that are implemented with these systems are: scheduled start/stop, optimized start/stop, duty cycling, demand limiting, day/night setback, and ventilation/recirculation.

*1. J. Rees. Controlling energy consumption in single buildings, Naval Civil Engineering Laboratory, Contract Report CR 82.028. Atlanta, Ga., Newcomb & Boyd, Jul 1982.

DISCUSSION

The Naval Civil Engineering Laboratory (NCEL) started investigating SBEC in FY77. A survey of existing equipment identified timeclocks and demand limiters as the only readily available alternatives to large-scale EMCS. Unfortunately, timeclocks are readily defeated through tampering or setting them to worst-case conditions, and they require significant O&M effort. Demand limiters typically lack flexibility and are primarily aimed at saving money on demand charges. Government buildings are rarely demand-metered on a building-by-building basis, and demand limiters typically lack flexibility to respond to changing demand billing structures or to be incorporated into an EMCS.

Because no product was available that met the desired characteristics, a development program was initiated to provide a microprocessor-based unit that would provide scheduled start/stop and optimized start/stop energy conservation control strategies. A contract was awarded to develop an intelligent timeclock (ITC). The original plan called for one ITC to be installed in Building 560 at NCEL and another one in the Thompson Laboratory building at NWC, China Lake.

One ITC was installed at NCEL and did validate the concept of using microcomputer technology to implement energy conservation control strategies. The primary strategy implemented on the ITC was optimized start/stop, which used outside air temperature, inside building air temperature, and time to determine the "optimum" time to start/stop the HVAC equipment. The development and installation of the ITC is detailed in Reference 2.*

Unfortunately, the ITC was not as reliable or maintainable as desired, so the decision was made not to install the other ITC at China Lake and to replace the ITC at NCEL. The ITC at NCEL was replaced with a unit assembled using single-board computer technology. The development, installation, and experience on this unit are described in Reference 3.**

A slightly different approach was taken for the unit to be installed at China Lake -- the Center used one of the commercially available SBECs that had become available since the development of the ITC. The SBEC selected for China Lake was the Andover Controls Sunkeeper. This unit has an excellent reputation for reliability and user satisfaction. The Sunkeeper is user programmable using a very simple, but adequate, control language with the following syntax:

```
Do action; if any of the following conditions are met GO TO LINE__
condition 1
condition 2
:
condition n
```

*2. D. Shiroma. EMCS modules/intelligent time clock (ITC), Civil Engineering Laboratory, Technical Note N-1588. Port Hueneme, Calif., Sep 1980.

**3. I. Sanchez. Utilizing the optimum start/stop control strategy for heating NCEL, Naval Civil Engineering Laboratory, Technical Note N-1663. Port Hueneme, Calif., Apr 1983.

or

Do action; if all of the following conditions are met GO TO LINE__
condition 1
condition 2
:
condition n

The Sunkeeper has the capability for 32 digital inputs (contact closures), 32 digital outputs (energize relays), and 32 analog inputs (temperature sensors).

A coordinated effort between NCEL and PWO China Lake resulted in the Sunkeeper being installed in the Public Works building instead of the Thompson Lab. The rationale behind this was to allow Public Works personnel to become familiar with using computerized energy conservation control strategies in their own building.

The Public Works building at China Lake has four large air handler units (AHU) that provide both heating and cooling to the building. PW personnel prepared the building by installing conduit between the location for the Sunkeeper and the motor control center for the air handlers. Two people from NCEL assisted China Lake personnel with the final installation of the Sunkeeper control unit, temperature sensors, and solid state interposing relays. A one-line diagram of the Sunkeeper installation is shown in Figure 1. The Sunkeeper was operational 28 October 1981.

NWC and NCEL personnel worked together to develop the control strategy for optimized start/stop and weekend/holiday shutdown. These control strategies were initially used on only one AHU on a trial basis and then the other three AHUs were added. In addition, NWC personnel have since implemented duty cycling.

The initial reaction to the Sunkeeper has been favorable, but that is not to say that there have not been problems. However, thanks to the dedication of the NWC Public Works personnel, telephone help from Andover Controls, and the cooperation of the building occupants, all problems have been overcome. In fact, the unit has been so successful that three additional Andover Controls units are being installed in other China Lake buildings. These other buildings are being monitored by NCEL in order to help determine the energy saved by implementing SBEC.

CONCLUSIONS

SBEC can help conserve energy in government buildings. Implementing a few energy conservation control strategies, such as scheduled start/stop, optimized start/stop, duty cycling, demand limiting, day/night setback, and ventilation/recirculation, can achieve significant energy savings. Strategies that have been successfully implemented at either NCEL or China Lake are: scheduled start/stop, optimized start/stop, deadband operation, weekend/holiday shutdown, and duty cycling. These strategies can be implemented by using a SBEC with temperature sensors and interposing relays in the HVAC control loops. Key ingredients for success are: (1) a good, reliable SBEC; (2) a dedicated, enthusiastic SBEC user; and (3) building occupants' patience and cooperation.

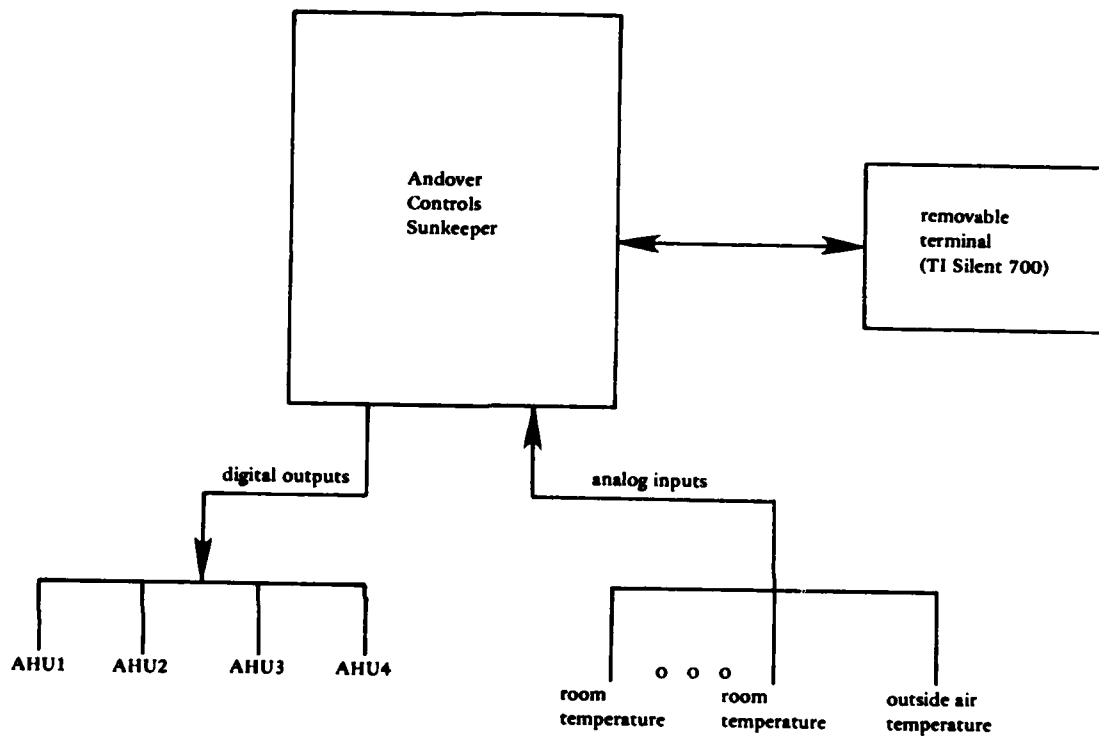


Figure 1. System one-line diagram.

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Alameda CA; Code 183 (Fac. Plan BR MGR); Code 183, Jacksonville FL; Code 18300, Lemoore CA 93245; Code 183P (J. Howald), Corpus Christi TX; Code 183P, Virginia Beach, VA; Code 18700, Brunswick ME; Code 18A, Miramar, San Diego CA; Code 18U (ENS P.J. Hickey), Corpus Christi TX; Code 70, Atlanta, Marietta GA; Code 8E, Patuxent Riv., MD; Dir of Engrng, PWD, Corpus Christi, TX; Dir. Util. Div., Bermuda; ENS L. Bochet, Kingsville TX; Grover, PWD, Patuxent River, MD; Lakehurst, NJ; Lead. Chief, Petty Offr, PW/Self Help Div, Beeville TX; PW (J. Maguire), Corpus Christi TX; PWD - Engr Div Dir, Millington, TN; PWD - Engr Div, Gtmo, Cuba; PWD - Engr Div, Kingsville, TX; PWD - Engr Div, Oak Harbor, WA; PWD - Maint Control Div, Glenview, IL; PWD - Maint Control Div, Moffett Field, CA; PWD Maint. Cont. Dir., Fallon NV; PWD Maint. Div., New Orleans, Belle Chasse LA; PWD, Maintenance Control Dir., Bermuda; PWO (Code 18.2), Bermuda; PWO Belle Chasse, LA; PWO Chase Field Beeville, TX; PWO Jacksonville, FL; PWO Key West FL; PWO Lakehurst, NJ; PWO Patuxent River MD; PWO Point Mugu, CA; PWO Sigonella Sicily; PWO Whidbey Is, Oak Harbor WA; PWO Whiting Fld, Milton FL; PWO, Aux Fallon, NV; PWO, Cecil Field FL; PWO, Corpus Christi TX; PWO, Dallas TX; PWO, Glenview IL; PWO, Millington TN; PWO, Miramar, San Diego CA; PWO, Oceana, Virginia Bch VA; PWO, So. Weymouth MA; PWO., Moffett Field CA; SCE Norfolk, VA; SCE Pensacola, FL; SCE, Alameda CA; SCE, Barbers Point HI; SCE, Cubi Point, R.P.; SCE, Guantanamo Bay Cuba; Weapons Offr, Alameda, CA

NASDC-WDC T. Fry, Manassas VA

NATL ACADEMY OF SCIENCES R S Shane (Nat'l Matl Adv Bd) Springfield, VA

NATL BUREAU OF STANDARDS Thermal Anal Gp, Wash. DC

NATL RESEARCH COUNCIL Naval Studies Board, Washington DC

NATNAVMEDCEN Code 43, Energy Conserv (PWO) Bethesda, MD

NAVACT CO (Code A171P), London, UK; PWO, London UK

NAVACTDET PWO, Holy Lock UK

NAVADMINCOM PWO Code 50, Orlando FL

NAVAEROSPREGMEDCEN SCE, Pensacola FL

NAVAIRDEVCEEN CO (Code 8323), Warminster, PA; Chmielewski, Warminster, PA; OIC/ROICC, Warminster PA; PWD, Engr Div Mgr, Warminster, PA

NAVAIRENGCEN Code 18 (PWO) Lakehurst, NJ

NAVAIRPROPTSTCEN CO (Code PW-3), Trenton NJ; CO, Trenton, NJ

NAVAIRSYSCOM Code NAIR 4012, Washington DC

NAVAIRTESTCENT Code CT106, Patuxent River, MD

NAVAL HOME SCE Gulfport, MS

NAVAUDSVCHO Director, Falls Church VA

NAVAVIONICFAC Code B/732

NAVCOASTSYSCEN CO (Code 352), Panama City, FL; CO, Panama City FL; Code 715 (J Quirk) Panama City, FL; Library Panama City, FL; PWO Panama City, FL

NAVCOMMAREAMSTRSTA CO (Energy Conserv), Naples, It.

NAVCOMMAREAMSTRSTA Code 41, Norfolk, VA; PWO, Norfolk VA; SCE Unit 1 Naples Italy; SCE, Guam; SCE, Wahiawa HI

NAVCOMMSTA CO (Code 20) San Diego, CA; CO (Code 314), Stockton, CA; CO (Code 401), Nea Makri, Greece; CO (PWD), Exmouth, Australia; CO, San Miguel, R.P.; Code 401 Nea Makri, Greece; OICC, Nea Makri Greece; PWD - Maint Control Div, Diego Garcia Is.; PWO Nea Makri, Greece; PWO, Exmouth, Australia; SCE, Balboa, CZ

NAVCOMMU PWD, Maint. Control Dir., Thurso, Scotland; PWO, Thurso, Scotland

NAVCOMMUNIT CO (Code 50), East Machias, ME; Power Plant - Cutler, East Machias, ME

NAVCONSTRACEN CO, Port Hueneme CA; Co, Gulfport MS; Curriculum/Instr. Stds Offr, Gulfport MS

NAVDET OIC (Energy Conserv), Souda, Bay, Crete; PWO, Souda Bay Crete

NAVDIVESALVCEN CO, Panama City FL

NAVEDTRAPRODEVCEEN SCE, Pensacola FL; Technical Library, Pensacola, FL

NAVEDUTRACEN CO, Code 44, Newport RI; Engr Dept (Code 42) Newport, RI; PWO Newport RI

NAVELEXSYSCOM Code ELEX 103 NAVFACENGCOORD, Washington, DC; ELEX 1033 Washington, DC

NAVEODTECHCEN Code 605, Indian Head MD

NAVFAC CO (APOWO), Pacific Beach, WA; CO (Code 04) Coos Head, Charleston, Or; CO (Code 05) Centerville Beach Fernadale, CA; CO (Code 300), Antigua; CO (Code 50A), Brawdy Wales, UK; CO (Code N67), Argentia Newfoundland; CO (Energy Conserv), Big Sur, CA; M & O Officer Bermuda; PWO Pacific Beach WA; PWO, Antigua; PWO, Brawdy Wales UK; PWO, Centerville Bch, Ferndale CA; PWO, Coos Head, Charleston OR; PWO, Point Sur, Big Sur CA

NAVFACENGCOM Alexandria, VA; Code 03 Alexandria, VA; Code 03T (Essoglou) Alexandria, VA; Code 04 Alexandria VA; Code 043 Alexandria, VA; Code 044 Alexandria, VA; Code 04B3 Alexandria, VA; Code 04T2 (Knapp), Alexandria, VA; Code 04T2B (McGrath), Alexandria, VA; Code 04T7B (Stickley), Alexandria, VA; Code 051A Alexandria, VA; Code 05D1 (Bersson), Alexandria, VA; Code 08, Alexandria VA; Code 09M54, Tech Lib, Alexandria, VA; Code 111 (Mitchum), Alexandria, VA; Code 1112E (Tayler), Alexandria, VA; Code 1113, Alexandria, VA; Code 111B (Hanneman), Alexandria, VA; Code 111B Alexandria, VA; code 08T Alexandria, VA

NAVFACENGCOM - CHES DIV, CO Code 11 Washington, DC; CO, Washington DC; Code 04, Wash. DC; Code 05, Wash, DC; Code 403 Washington DC; Code 406 Washington DC; FPO-1 Washington, DC;

Library, Washington, D.C.; RDT&ELO Wash. DC

NAVFACENGCOM - LANT DIV. Code 04 Norfolk VA Norfolk VA; Code 04, Norfolk, VA; Code 05, Norfolk, VA; Code 11, Norfolk, VA; Code 111, Norfolk, VA; Code 403, Norfolk, VA; Eur. BR Deputy Dir. Naples Italy; Library, Norfolk, VA; Norfolk, VA; RDT&ELO 102A, Norfolk, VA

NAVFACENGCOM - NORTH DIV. Asst. Dir., Great Lakes IL; CO; Code 04 Philadelphia, PA; Code 04AL, Philadelphia PA; Code 05, Phila, PA; Code 09P Philadelphia PA; Code 11, Phila PA; Code 111 Philadelphia, PA; Code III WFT (Tayler), Phila PA; ROICC, Contracts, Crane IN

NAVFACENGCOM - PAC DIV. (Kyi) Code 101, Pearl Harbor, HI; CODE 09P PEARL HARBOR HI; Code 04 Pearl Harbor HI; Code 05, Pearl Harbor, HI; Code 11 Pearl Harbor HI; Code 111:SI, Pearl Harbor, HI; Code 402, RDT&E, Pearl Harbor HI; Commander, Pearl Harbor, HI; Library, Pearl Harbor, HI

NAVFACENGCOM - SOUTH DIV. CO, Charleston SC; Code 04, Charleston, SC; Code 05, Charleston, SC; Code 11, Charleston, SC; Code 403, Gaddy, Charleston, SC; Code 406 Charleston, SC; Code 90, RDT&ELO, Charleston SC; Library, Charleston, SC

NAVFACENGCOM - WEST DIV. AROICC, Contracts, Twentynine Palms CA; CO (Code 1113), San Bruno, CA; Code 04, San Bruno, CA; Code 04B San Bruno, CA; Code 05, San Bruno, CA; Code 11 San Bruno, CA; Code 1121 San Bruno, CA; Library, San Bruno, CA; 09P/20 San Bruno, CA; RDT&ELO Code 2011 San Bruno, CA; San Bruno, CA; Seattle Br, Silverdale, WA

NAVFACENGCOM CONTRACTS AROICC, NAVSTA Brooklyn, NY; AROICC, Quantico, VA; Contracts, AROICC, Lemoore CA; Dir, Eng. Div., Exmouth, Australia; Dir. of Constr. Tupman, CA; Eng Div dir, Southwest Pac, Manila, PI; OICC Trident, Alexandria VA; OICC, Guam; OICC, Kings Bay, GA; OICC, Southwest Pac, Manila, PI; OICC-ROICC, NAS Oceana, Virginia Beach, VA; OICC ROICC, Balboa Panama Canal; OICC ROICC, Norfolk, VA; R40 AROICC Puget Sound Shpyd; ROICC AF Guam; ROICC Code 495 Portsmouth VA; ROICC Key West FL; ROICC, Code 1042 2, Vallejo CA; ROICC, Code 7002, China Lake CA; ROICC, Keflavik, Iceland; ROICC, NAS, Corpus Christi, TX; ROICC, Pacific, San Bruno CA; ROICC, Yap; ROICC-OICC-SPA, Norfolk, VA

NAVFACENGCOMHQ Code 04T2A, Alexandria, VA

NAVFEELDEP OIC (Energy Conserv), JAX, FL

NAVHOSP APWO (Code 13), Beaufort SC

NAVINACTSHIPSTORFAC PWO, Orange TX

NAVMAG PWD - Engr Div, Guam; SCE, Guam; SCE, Subic Bay, R.P.

NAVMEDRSCHU 3 PWO, Cairo Egypt

NAVOBSY Code 67, Washington DC

NAVOCEANSYSCEN Code 4473B (Tech Lib) San Diego, CA; Code 523 (Hurley), San Diego CA; Code 6700, San Diego, CA; Code 811 San Diego, CA; Commander (Code 411), San Diego, CA

NAVORDFAC CO (Code 66), Sasebo, Japan

NAVORDMISTESTFAC Fac Supp Div, White Sands Missile Range, NM; PWD - Engr Dir, White Sands, NM

NAVORDSTA CO (Code 0931), Louisville, KY; Code 0923, Indianhead, MD; MDS-25, Mfg Tech Dept Louisville, KY; PWD - Dir, Engr Div, Indian Head, MD; PWO, Louisville KY

NAVORDSYSCOM Code SPL-631

NAVPEOFF Code 30, Alexandria VA

NAVPEURES Director, Washington DC

NAVPGSCOL Code 43B, Monterey, CA; PWO Monterey CA

NAVPHIBASE CO (PWO), Norfolk, VA; CO, ACB 2 Norfolk, VA; PWO Norfolk, VA; SCE Coronado, SD, CA

NAVPLANTREP Hercules Inc., Magna, UT

NAVRADSTA PWO Jim Creek, Oso WA

NAVREGMEDCEN CO (Code 133), Long Beach, CA; CO (Code 93), Camp Lejeune, NC; CO (Code A09) - Engr Div, Phila., PA; Chief, PW Service Philadelphia, PA; Code 3041, Memphis, Millington TN; Code 310, Portsmouth, VA; PWD - Engr Div, Camp Lejeune, NC; PWD - Engr Div, Camp Pendleton, CA; PWD - Maint Control Div, Camp Pendleton, CA; PWD - Maint. Control Div, Phila, PA; PWO, Camp Lejeune, NC

NAVREGMEDCEN PWO, Okinawa, Japan

NAVREGMEDCEN SCE; SCE San Diego, CA; SCE, Camp Lejeune NC; SCE, Camp Pendleton CA

NAVREGMEDCEN SCE, Great Lakes IL

NAVREGMEDCEN SCE, Guam; SCE, Long Beach CA; SCE, Newport, RI; SCE, Oakland CA

NAVREGMEDCEN SCE, Yokosuka, Japan

NAVRESREDCOM Commander (Code 07), Great Lakes, IL; Commander (Code 072), San Francisco, CA

NAVSCOLCECOFF C35 Port Hueneme, CA

NAVSCSCOL CO (Code 50), Athens, GA

NAVSCSOL PWO, Athens GA

NAVSEASYSYSCOM Code 0325, Program Mgr, Washington, DC; Code 03314, Wash. D C; Code PMS 395 A 3, Washington, DC; PMS-396/33 Washington DC; SEA 04E (L Kess) Washington, DC

NAVSECGRUACT CO (Code 30), Puerto Rico; CO (Code 40B), Edzell, Scotland; CO (Code N60), Homestead, FL; CO (Energy Conserv), Sonoma, CA; CO (Energy Conserv.) Winter Harbor, ME; CO (PWD), Adak, AK; Code 40, Chesapeake, VA; PWO Winter Harbor ME; PWO, Adak AK; PWO, Edzell Scotland, PWO, Puerto Rico; PWO, Skaggs Is, Sonoma CA, PWO, Torri Sta, Okinawa

NAVSECGRUCOM Energy Conserv., Washington DC

NAVSECSTA Code 540, Washington DC; PWD - Engr Div, Wash., DC

NAVSHIPYD CO (Code 405); Code 202.4, Long Beach CA; Code 202.5 (Library) Puget Sound, Bremerton WA; Code 380, Portsmouth, VA; Code 382.3, Pearl Harbor, HI; Code 400, Puget Sound; Code 402.4, Philadelphia PA; Code 410, Mare Is., Vallejo CA; Code 440 Portsmouth NH; Code 440, Norfolk; Code 440, Puget Sound, Bremerton WA; Code 440.1 (R. Schwinck), Long Beach, CA; Code 444, (Wgt Handling Engr) Philadelphia, PA; Code 453 (Util. Supr), Vallejo CA; Code 457 (Maint. Supr.) Mare Island, Vallejo CA; Commander (Code 406), Portsmouth, NH; LTJG R. Lloyd, Vallejo CA; Library, Portsmouth NH; PW Dept, Long Beach, CA; PWD (Code 400.03), Charleston SC; PWD (Code 420) Dir Portsmouth, VA; PWD (Code 450-HD) Portsmouth, VA; PWD (Code 453-HD) SHPO 03, Portsmouth, VA; PWD - Asst PWO, Code 410, Vallejo, CA; PWD - Code 450, Bremerton, WA; PWD - Engr Div, Code 440, Vallejo, CA; PWD - Utilities Supt, Code 903, Long Beach, CA; PWO Charleston Naval Shipyard, Charleston SC; PWO, Bremerton, WA; PWO, Mare Is.; PWO, Portsmouth NH; PWO, Puget Sound; Puget Sound, CMDR (Code 402.3), Bremerton, WA; SCE, Pearl Harbor HI; Tech Library, Vallejo, CA; Utilities & Energy Cons, Mgr Code 108.1, Pearl Harbor, HI

NAVSTA (Code 50A) Rodman, Panama Canal; Adak, AK; CO (Code 18410), Mayport, FL; CO (Code 413), Grmo, Cuba; CO (Code 52), Brooklyn NY; CO (Code ODE), San Diego, CA; CO (Energy Conserv); CO (PWD), Keflavik, Iceland; CO (PWD), Rota, Spain; CO, Brooklyn NY; Code 16P, Keflavik, Iceland; Code 4, 12 Marine Corps Dist, Treasure Is., San Francisco CA; Dir Engr Div, PWD, Mayport FL; Dir Mech Engr 37WC93 Norfolk, VA; Engr. Dir. Rota Spain; Long Beach, CA; Maint. Cont. Div., Guantanamo Bay Cuba; Maint. Control Div., Adak; Maintenance Div., Rota, Spain; PWD - Engr Dept, Adak, AK; PWD - Engr Div, Midway Is.; PWD, Utilities Div., Guantanamo Bay Cuba; PWO, Adak, AK; PWO, Brooklyn NY; PWO, Keflavik Iceland; PWO, Mayport FL; SCE, Guam; SCE, Pearl Harbor HI; SCE, San Diego CA; SCE, Subic Bay, R.P.

NAVSUBASE CO (Code 803), Groton, CT; PWO; PWO Bangor, Bremerton, WA

NAVSUPPACT CO (Code 413), Seattle, WA; CO (Code 81), Mare Island, Vallejo, CA; CO (Code N52), New Orleans, LA; CO (Energy Conserv), Naples, Italy; CO, Naples, Italy; PWO Naples Italy; PWO, Mare Is., Vallejo CA; PWO, New Orleans LA

NAVSUPPBASE CO (Energy Conserv) Kings Bay, GA

NAVSUPPFAC CO (Energy Conserv) Diego Garcia I; Code 02, Thurmont, MD; PWD - Maint. Control Div, Thurmont, MD; PWO, Thurmont MD

NAVSUPPO CO (APWO), La Maddalena, Italy

NAVSURFWPNCEN Dahlgren Lab, WW-02 Dahlgren VA; PWO, White Oak, Silver Spring, MD

NAVTECHTRACEN Code N213 Orlando FL; SCE, Pensacola FL

NAVTELCOMMCOM Code 05, Washington DC; Code 53, Washington, DC

NAVUSEAWARENGSTA CO (Code 073E2), Keyport, WA; Engr. Div. (Code 083) Keyport, WA; PWO, Keyport WA

NAVWARCOL Dir. of Facil., Newport RI

NAVWPNCEN Code 2634, China Lake, CA; Code 2636 China Lake; Code 3803 China Lake, CA; Commander (Code 2635), China Lake, CA; PWO (Code 266) China Lake, CA; ROICC (Code 702), China Lake CA

NAVWPNSTA (Clebak) Colts Neck, NJ; CO (Code 09221), Concord, CA; CO (Energy Conserv) Yorktown, VA; CO (Energy Conserv), Colts Neck, NJ; Code 0911, Seal Beach CA; Code 092A, Seal Beach, CA

NAVWPNSTA PW Office Yorktown, VA

NAVWPNSTA PWD - Maint. Control Div., Concord, CA; PWD - Supr Gen Engr, Seal Beach, CA; PWO Colts Neck, NJ; PWO, Charleston, SC; PWO, Seal Beach CA

NAVWPNSUPPCEN CO (Code 092E), Crane, IN; Code 09 Crane IN; ENS J. Wyman, Crane IN

NAVY PAO CENTER Directory, San Diego, CA

NCTC Const. Elec. School, Port Hueneme, CA

NCBC CO (Code 80), Port Hueneme, CA; CO (Energy Conserv), Davisville, RI; CO, Gulfport MS; Code 10 Davisville, RI; Code 15, Port Hueneme CA; Code 155, Port Hueneme CA; Code 156, Port Hueneme, CA; Code 25111 Port Hueneme, CA; Code 430 (PW Engrng) Gulfport, MS; Code 470.2, Gulfport, MS; NEESA Code 252 (P Winters) Port Hueneme, CA; PWO (Code 80) Port Hueneme, CA; PWO (Code 82), Port Hueneme CA; PWO - Code 84, Port Hueneme, CA; PWO, Davisville RI; PWO, Gulfport, MS; Port Hueneme CA

NCBU 416 OIC, Alameda CA

NCR 20, Code R31 Gulfport, MS

NMCB 1, CO; 1, Code S3E; 133, CO; 62, CO; 74, ENS Vesely; FIVE, Operations Dept; THREE, Operations Off.

NOAA Library Rockville, MD

NRL Code 5800 Washington, DC; PWO Code 2530.1, Washington, DC

NSC CO (Code 46A) San Diego, CA; CO (Code 70A), Puget Sound, WA; Code 54.1 Norfolk, VA; Code 703 (J. Gammon) Pearl Harbor, HI; SCE (Code 70), Oakland CA; SCE Norfolk, VA; SCE, Charleston, SC; SCE, Guam

NSD CO (Code 50E); PWD - Engr Div, Guam; SCE, Subic Bay, R.P.

NSWSES Code 0150 Port Hueneme, CA

NTC CO (Code NAC50F) Orlando, FL; SCE, San Diego CA

NTIS Lehmann, Springfield, VA

NUSC CO (Code 5204), Newport, RI; Code 131 New London, CT; Code 4123 New London, CT; Code 5202 (S. Schady) New London, CT; Code EA123 (R.S. Munn), New London CT; Code SB 331 (Brown), Newport RI; PWO AUTEC West Palm Bch Det. West Palm Beach, FL; PWO New London, CT; PWO Newport, RI; SB322 (Tucker), Newport RI
 OFFICE SECRETARY OF DEFENSE DASD (I&H) IC Pentagon; OASD (MRA&L) Dir. of Energy, Pentagon, Washington, DC
 ONR CO (Code 701) Pasadena, CA; Code 221, Arlington VA; Code 700F Arlington VA; LCDR Williams, Boston, MA
 PACMISRAFAC CO (Code 7031), Kekaha, HI; HI Area Bkg Sands, PWO Kekaha, Kauai, HI
 PHIBCB 1 P&E, San Diego, CA
 PMTC Commander (Code 6200-3), Point Mugu, CA
 PWC ACE Office Norfolk, VA; CO (Code 1003), Oakland, CA; CO (Code 100E), San Diego, CA; CO (Code 100E3), Oakland, CA; CO (Code 153), Guam; CO (Code 30), Pearl Harbor, HI; CO (Code 601), Subic Bay; CO (Code 610), Pensacola, FL; CO (Code 613), San Diego, CA; CO Norfolk, VA; CO Yokosuka, Japan; CO (Code 10), Oakland, CA; CO, Great Lakes IL; CO, Pearl Harbor HI; CO, San Diego CA; CO, Subic Bay, R.P.; Code 10, Great Lakes, IL; Code 100A, Great Lakes, IL; Code 101, San Diego, CA; Code 105 Oakland, CA; Code 105, Oakland, CA; Code 110, Great Lakes, IL; Code 110, Oakland, CA; Code 116, Seattle, WA; Code 120, Oakland CA; Code 120, San Diego CA; Code 154 (Library), Great Lakes, IL; Code 200 (H. Koubenec), Great Lakes IL; Code 200, Great Lakes IL; Code 400, Great Lakes, IL; Code 400, Oakland, CA; Code 400, Pearl Harbor, HI; Code 400, San Diego, CA; Code 420, Great Lakes, IL; Code 420, Oakland, CA; Code 420, Pensacola, FL; Code 420, San Diego, CA; Code 424, Norfolk, VA; Code 500 Norfolk, VA; Code 500, Great Lakes, IL; Code 500, Oakland, CA; Code 505A Oakland, CA; Code 600, Great Lakes, IL; Code 600A Norfolk, VA; Code 610, San Diego CA; Code 700, Great Lakes, IL; Library, Code 120C, San Diego, CA; Library, Guam; Library, Norfolk, VA; Library, Oakland, CA; Library, Pearl Harbor, HI; Library, Pensacola, FL; Library, Subic Bay, R.P.; Library, Yokosuka JA; Maint. Control Dept (R. Fujii) Pearl Harbor, HI; NAS Pensacola, FL; Util Dept (R Pascua) Pearl Harbor, HI; Utilities Officer, Guam
 SPCC CO (Code 763), Mechanicsburg, PA; PWD - Maint. Control Div, Mechanicsburg, PA; PWO (Code 120) Mechanicsburg PA
 SUPANX PWO, Williamsburg VA
 SUPSHIP ADMINO, San Francisco, CA; Code 901
 IVA Smelser, Knoxville, Tenn.; Solar Group, Arnold, Knoxville, TN
 AF HQ USAF DEE, Ramstein GE
 U.S. MERCHANT MARINE ACADEMY Kings Point, NY (Reprint Custodian)
 USAF AFRCE/CR (Walton), Dallas, TX; AFRCE/ER (Burns), Atlanta, GA; AFRCE/M-X (Stevens), Norton AFB, CA; AFRCE/WR (Lowry), San Francisco, CA
 USAF REGIONAL HOSPITAL Fairchild AFB, WA
 USAF HQ DEE (EMCS Mgr), Ramstein AFB, Germany
 USCG (Smith), Washington, DC; G-MMT-4/82 (J Spencer)
 USCG ACADEMY Utilities Section New London, CT
 USDA For. Prod. Lab. (Fac Engr), Madison, WI; Forest Service (R-1), Missoula, MT; Forest Service (R-10), Juneau, AK; Forest Service (R-2), Lakewood, CO; Forest Service (R-3), Albuquerque, NM; Forest Service (R-4), Ogden, UT; Forest Service (R-5), San Francisco, CA; Forest Service (R-6), Portland, OR; Forest Service (R-9), Milwaukee, WI; Forest Service Reg 3 (R. Brown) Albuquerque, NM; Forest Service Reg 6 Hendrickson, Portland, OR; Forest Service, Region 1, Missoula, MT; Forest Service, Region 4, Ogden, UT; Forest Service, Region 5, San Francisco, CA; Forest Service, Region 9, Milwaukee, WI; No. Cent. For. Exp. Sta., St. Paul, MN; Northeast. For. Exp. Sta., Broomall, PA; Pac. NW F&R Exp. Sta., Portland, OR; Rocky Mtn F&S Exp. Sta., Ft. Collins, CO; SE Forest Exp. Sta., Asheville, NC
 USNA Ch. Mech. Engr. Dept Annapolis MD; Code 170, Annapolis, MD; ENGRNG Div, PWD, Annapolis MD; Energy-Environ Study Grp, Annapolis, MD; Environ. Prot. R&D Prog. (J. Williams), Annapolis MD; Mech. Engr. Dept. (C. Wu), Annapolis MD; PWD Suprt. Annapolis MD; USNA/SYS ENG DEPT ANNAPOLIS MD
 USPS Postmaster (Mgr Plant Maint), Albany, GA
 USS FULTON WPNS Rep. Offr (W-3) New York, NY
 ALABAMA ENERGY MGT BOARD Montgomery, AL
 ARIZONA Kroelinger Tempe, AZ; State Energy Programs Off., Phoenix AZ
 AUBURN UNIV. Bldg Sci Dept, Lechner, Auburn, AL
 BERKELEY PW Engr Div, Harrison, Berkeley, CA
 BONNEVILLE POWER ADMIN Portland OR (Energy Consv. Off., D. Davey)
 BROOKHAVEN NATL LAB M. Steinberg, Upton NY
 CALIFORNIA STATE UNIVERSITY LONG BEACH, CA (CHELAPATI)
 CLEMSON UNIV. Col. Arch., Egan, Clemson, SC
 CONNECTICUT Office of Policy & Mgt. Energy, Div, Hartford, CT
 CORNELL UNIVERSITY Ithaca NY (Serials Dept, Engr Lib.)
 DAMES & MOORE LIBRARY LOS ANGELES, CA
 DRURY COLLEGE Physics Dept, Springfield, MO

FLORIDA ATLANTIC UNIVERSITY Boca Raton, FL (McAllister)
 FOREST INST. FOR OCEAN & MOUNTAIN Carson City NV (Studies - Library)
 FRANKLIN INSTITUTE M. Padusis, Philadelphia PA
 GEORGIA INSTITUTE OF TECHNOLOGY (LT R. Johnson) Atlanta, GA; Col. Arch, Benton, Atlanta, GA
 HARVARD UNIV. Dept. of Architecture, Dr. Kim, Cambridge, MA
 HAWAII STATE DEPT OF PLAN. & ECON DEV. Honolulu HI (Tech Info Ctr)
 IOWA STATE UNIVERSITY Dept. Arch. McKrown, Ames, IA
 WOODS HOLE OCEANOGRAPHIC INST. Woods Hole MA (Winget)
 KEENE STATE COLLEGE Keene NH (Cunningham)
 LAWRENCE BERK LAB Window & Lighting Prog. Berkeley, CA
 LEHIGH UNIVERSITY Bethlehem PA (Linderman Lib. No.30, Flecksteiner)
 LOS ALAMOS SCI LAB Solar Energy Gp. Los Alamos, NM
 LOUISIANA DIV NATURAL RESOURCES & ENERGY Div Of R&D, Baton Rouge, LA
 MAINE OFFICE OF ENERGY RESOURCES Augusta, ME
 MISSOURI ENERGY AGENCY Jefferson City MO
 MIT Cambridge MA (Rm 10-500, Tech. Reports, Engr. Lib.); Cambridge, MA (Harleman)
 MONTANA ENERGY OFFICE Anderson, Helena, MT
 NATURAL ENERGY LAB Library, Honolulu, HI
 NEW HAMPSHIRE Concord NH (Governor's Council on Energy)
 NEW MEXICO SOLAR ENERGY INST. Dr. Zwibel Las Cruces NM
 NY CITY COMMUNITY COLLEGE BROOKLYN, NY (LIBRARY)
 NYS EMERGENCY FUEL OFFICE Albany NY (Butler)
 NYS ENERGY OFFICE Albany, NY; Library, Albany NY
 OAK RIDGE NATL LAB T. Lundy, Oak Ridge, TN
 PORT SAN DIEGO Pro Eng for Port Fac, San Diego, CA
 PURDUE UNIVERSITY Lafayette, IN (CE Engr. Lib)
 SCRIPPS INSTITUTE OF OCEANOGRAPHY LA JOLLA, CA (ADAMS)
 SEATTLE U Prof Schwaegler Seattle WA
 STATE UNIV. OF NEW YORK Fort Schuyler, NY (Longobardi)
 TENNESSEE ENERGY AUTHORITY Nashville, TN
 TEXAS A&M UNIVERSITY W.B. Ledbetter College Station, TX
 UNIVERSITY OF CALIFORNIA Energy Engineer, Davis CA; LIVERMORE, CA (LAWRENCE
 LIVERMORE LAB, TOKARZ); UCSF, Physical Plant, San Francisco, CA
 UNIVERSITY OF DELAWARE Newark, DE (Dept of Civil Engineering, Chesson)
 UNIVERSITY OF FLORIDA Dept Arch., Morgan, Gainesville, FL
 UNIVERSITY OF HAWAII HONOLULU, HI (SCIENCE AND TECH. DIV.)
 UNIVERSITY OF ILLINOIS (Hall) Urbana, IL; URBANA, IL (LIBRARY)
 UNIVERSITY OF MASSACHUSETTS (Heronemus), ME Dept. Amherst, MA
 UNIVERSITY OF NEBRASKA-LINCOLN Lincoln, NE (Ross Ice Shelf Proj.)
 UNIVERSITY OF NEW HAMPSHIRE Elec. Engr. Depot, Dr. Murdoch, Durham, N.H.
 UNIVERSITY OF TEXAS Inst. Marine Sci (Library), Port Arkansas TX
 UNIVERSITY OF TEXAS AT AUSTIN AUSTIN, TX (THOMPSON)
 UNIVERSITY OF WASHINGTON Insti. for Envir. Studies; Seattle WA (E. Linger)
 UNIVERSITY OF WISCONSIN Milwaukee WI (Ctr of Great Lakes Studies)
 VENTURA COUNTY Plan Div (Francis) Ventura, CA
 ARVID GRANT OLYMPIA, WA
 ATLANTIC RICHFIELD CO. DALLAS, TX (SMITH)
 BECHTEL CORP. SAN FRANCISCO, CA (PHELPS)
 CHEMED CORP Lake Zurich IL (Dearborn Chem. Div.Lib.)
 COLUMBIA GULF TRANSMISSION CO. HOUSTON, TX (ENG LIB.)
 DESIGN SERVICE; Beck, Ventura, CA
 DIXIE DIVING CENTER Decatur, GA
 DURLACH, O'NEAL, JENKINS & ASSOC. Columbia SC
 GARD INC. Dr. L. Holmes, Niles, IL
 LITHONIA LIGHTING Application eng. Dept. (B. Helton), Conyers, GA 30207
 McDONNELL AIRCRAFT CO. (Fayman) Engrng Dept., St. Louis, MO
 MEDERMOTT & CO. Diving Division, Harvey, LA
 NEWPORT NEWS SHIPBLDG & DRYDOCK CO. Newport News VA (Tech. Lib.)
 PACIFIC MARINE TECHNOLOGY (M. Wagner) Duvall, WA
 PG&E Library, San Francisco, CA
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